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NOISE REDUCTION OF THE XM759 CARGO CARRIER (MARGINAL TERRAIN VEHICLE)

Howard H. Holland, Jr.

July 1970

HUMAN ENGINEERING LABORATORIES

ABERDEEN RESEARCH & DEVELOPMENT CENTER

ABERDEEN PROVING GROUND, MARYLAND

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ABSTRACT

Noise was reduced on the XM759 Cargo Carrier (Marginal Terrain Vehicle) by changing the type of engine cooling fan, applying acoustical attenuating material, and using a noise attenuator. The main noise source is the engine cooling fan. Pilot Vehicles 1, 2, 3, and 6 were involved in this noise reduction program, which began in December 1967 and is still in progress.

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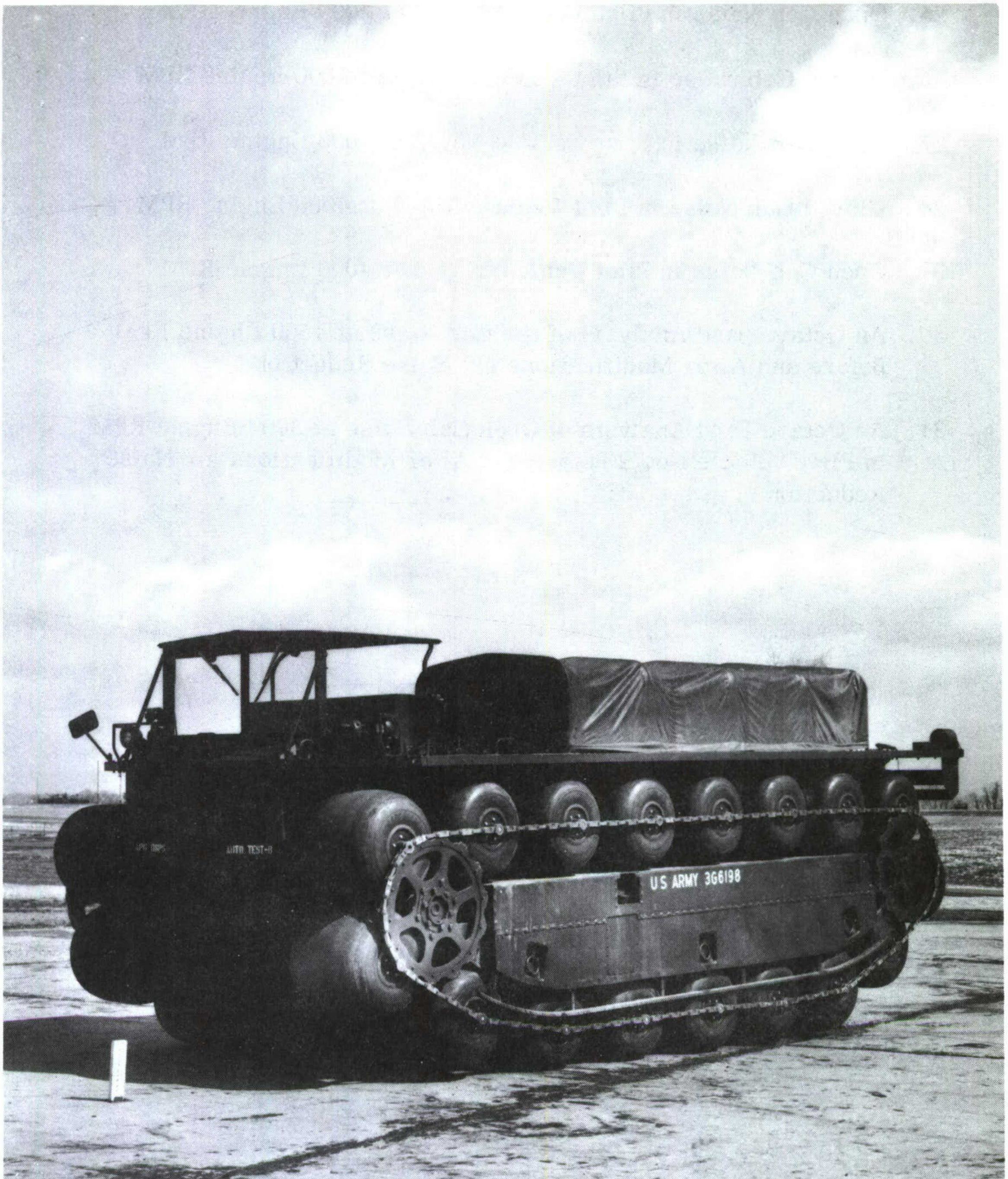

Fig. 1. THE XM759 CARGO CARRIER (MARGINAL TERRAIN VEHICLE)
PILOT VEHICLE NO. 3

NOISE REDUCTION OF THE XM759 CARGO CARRIER

(MARGINAL TERRAIN VEHICLE)

INTRODUCTION

Noise evaluation of the XM759 Cargo Carrier was begun in December 1967 as requested by the U. S. Army Test and Evaluation Command. The purpose of the evaluation was to determine the sound pressure level (SPL) by octave bands for comparison with the Human Engineering Laboratories (HEL) Standard S-1-63B, "Maximum Noise Level for Army Materiel Command Equipment." The XM759 Cargo Carrier exceeded some of the levels of Table 2, "Maximum Steady State Noise Level for Army Materiel Command Equipment," of HEL Standard S-1-63B. After learning that the vehicle noise exceeded the standard, the purpose of further tests was to isolate noise sources and reduce the noise levels below the specified levels in Table 2, HEL Standard S-1-63B.

The noise evaluation consisted of the following tests:

a. Initial noise measurements with Pilot Vehicle No. 3 in December 1967 at Aberdeen Proving Ground, Md. (Fig. 1).

b. Measurements with Pilot Vehicle No. 6 in May 1968 at Fort Lee, Va. Acoustical material was added to the exhaust air shroud and the engine compartment.

c. Measurements with Pilot Vehicle No. 6 in July 1968 at Fort Lee and Dillon's Landing, Va. A mixed-flow engine cooling fan was substituted for the vane-axial fan, and the air intake was modified.

d. Measurements with Pilot Vehicle No. 1 in August 1968 at Aberdeen Proving Ground, Md. with and without acoustical material in the exhaust air shroud.

e. Measurements with Pilot Vehicle No. 6 in July and August 1969 at Aberdeen Proving Ground with and without acoustical material. A modified mixed-flow engine cooling fan replaced the mixed-flow fan previously used.

f. Measurements with Pilot Vehicle No. 2 between August and December 1969 at Aberdeen Proving Ground with and without acoustical material. This vehicle has a vane-axial engine cooling fan in a location different from that of the other pilot vehicles.

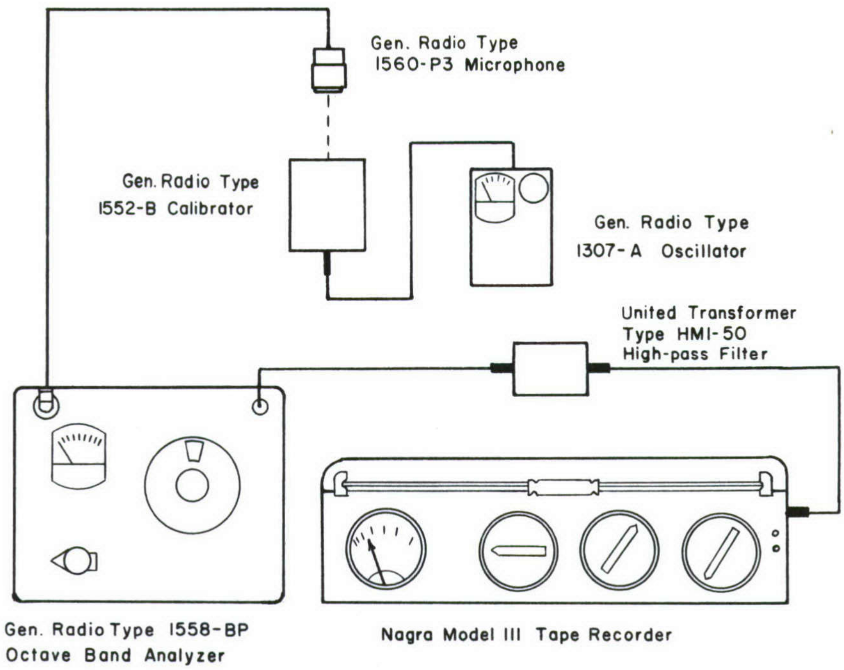

Fig. 2. SCHEMATIC DIAGRAM OF A TYPICAL MEASURING SYSTEM USED FOR MEASUREMENTS OF THE NOISE LEVELS OF THE XM759 CARGO CARRIER

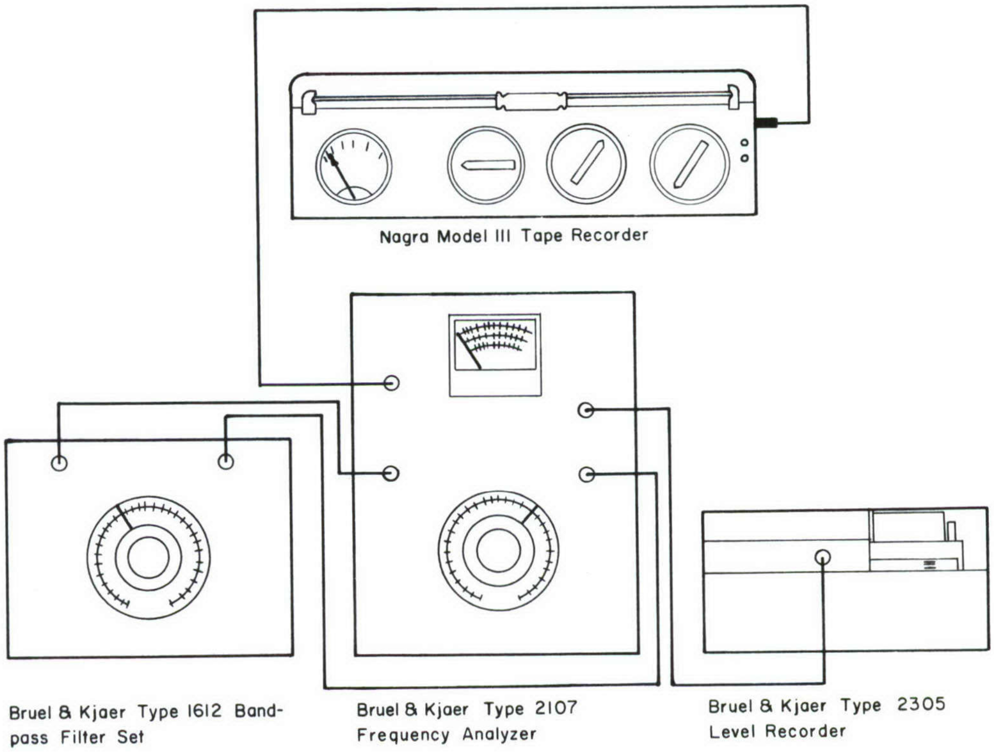

Fig. 3. ANALYZING SYSTEM FOR AUTOMATIC ANALYSIS OF THE XM759 CARGO CARRIER NOISE

METHOD

Apparatus

The measuring system used in this noise-reduction program consisted of a General Radio (GR) octave-band analyzer and microphone. A Nagra Model III tape recorder was added to the system for some of the measurements to obtain recordings which could be played back for narrow-band analyses. The particular type or model number of the analyzer and microphone are given below for each individual set of measurements. A typical measuring system is shown in Figure 2.

The analyzing system consisted of the Bruel & Kjaer (B&K) equipment shown in Figure 3 plus the Nagra Model III recorder.

Procedure

All of the cab measurements were made with the microphone located midway between the heads of the driver and the assistant driver (Fig. 4). In most cases, the microphone was suspended from the cab ceiling with the microphone facing down. In a few cases when the cab was completely open and there was nothing over the drivers' heads, the microphone was held by hand, facing up, midway between the drivers' heads.

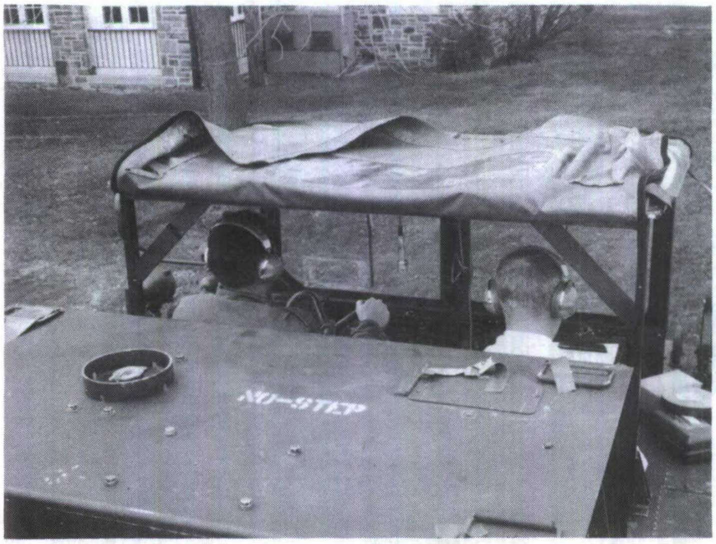

Fig. 4. VIEW OF THE MICROPHONE MIDWAY BETWEEN THE DRIVERS' HEADS WITH CURTAINS UP (OPEN CAB)

The cargo-area measurements are described in the description of the individual tests.

All of the rpm's referred to in this report are engine rpm's. The only test made with the vehicle in motion was during the December 1967 test. The other tests were conducted with the vehicle stationary and the engine operating.

Pilot Vehicle No. 3 Test -- December 1967

This test was conducted during the period 6-18 December 1967 at the Three Mile Straightway, Perryman Test Course, Aberdeen Proving Ground, Md. The measuring system consisted of a GR Type 1551-P4 piezoelectric ceramic microphone, a GR Type 1558-AP octave-band noise analyzer, a United Transformer Type HMI-50 high pass filter, and a Nagra Model III tape recorder.

SPL's were recorded in the cargo area with the cover on and the microphone located two feet from the engine compartment, four feet above the floor, and on the fore-aft centerline of the vehicle. The vehicle operating conditions were with the engine idling and the vehicle stationary and with the vehicle moving at 4, 5, 9, 10 and 15 mph.

The cab noise levels were recorded with the assistant driver's curtain and the rear curtain on and the driver's curtain off. The vehicle was stationary and the engine was operated at 1000, 2000, 3000, 4000 and 4500 rpm. The fan belts were then removed and the engine operated at 3000 and 4000 rpm with the engine cooling fan inoperative.

The next test condition was with a slightly larger non-standard fan-belt pulley substituted for the standard pulley so that the fan speed was decreased about 10 percent. SPL's for this condition were recorded in the cab at 0 mph and at 1000, 2000, 3000, 4000 and 4500 rpm.

Cab noise levels were again recorded with the vehicle moving and with the standard fan-belt pulley installed. The road speeds were 5, 9, 11 and 12 mph. Higher speeds could not be attained because of transmission trouble. The curtains were on the cab for this portion of the test (driver's curtain may have been off). Noise-level recordings were made in the cab with the curtains off at a road speed of 12 mph and also at 0 mph at 2250 and 2600 rpm.

Pilot Vehicle No. 6 Test -- May 1968

These cab and cargo area measurements were made at Fort Lee, Va., beginning 6 May 1968. The tests were halted 9 May 1968 because of a faulty hydraulic pump and continued during the period 14-16 May 1968.

The engine was run at idling speed, 1000, 2000, 3000, 4000 and 4500 rpm. The SPL was measured in the cargo area at a point two feet from the engine compartment bulkhead, four feet above the floor, on the fore-aft centerline.

Test 1 was made with one-inch glass-fiber material installed in the exhaust air ducting from the engine compartment. Measurements were made in the cab with the curtains down and with the curtains up, and in the cargo area with the cargo cover on and the cargo cover off.

Test 2 was made with the installation of material of Test 1 plus more of the same material cemented to the right side of the engine compartment wall wherever possible and three pieces of the material in the radiator shroud. One piece was cemented to the upper interior shroud surface 4 to 11 inches behind the air intake. This piece is also between the muffler and the vertical inboard wall of the shroud. A second piece was cemented to the vertical inboard wall of the shroud next to the first piece and perpendicular to it. The third piece was installed forward of the radiator below the deck level.

Test 3 was made with the Test 1 and Test 2 glass-fiber installation plus more material cemented to the engine side of the drivers' seat structure (behind seats).

Test 4 was made with the Test 1, 2 and 3 material installed plus material installed on the engine side of the aft fire wall and access door. All of the glass-fiber material was painted with cement to prevent the exhaust air stream from removing the material. Measurements were also made during this test in the cab with the fan disconnected and the engine run at 3000 and 4000 rpm. The cab curtains were down during these measurements.

All of the SPL's were read from the octave-band analyzer, GR Type 1558-BP. The GR Type 1560-P6 microphone system was used with the analyzer. Some of the test runs were tape recorded with the Nagra III recorder.

Pilot Vehicle No. 6 Test -- July 1968

These cab measurements were made at Fort Lee, Va., and at Dillon's Landing, Va. (near Providence Forge, Va.). The measurements at Fort Lee were made 15 July 1968 and those at Dillon's Landing 24 July 1968.

The engine was run at idling speed, 1000, 2000, 3000, 4000 and 4500 rpm for the tests with the standard air intake. The idling and 1000 rpm engine speeds were omitted for the tests with the modified air intake. All of the one-inch glass-fiber acoustical material that was installed in the vehicle for the May 1968 measurements was in the vehicle for these measurements.

The first tests were made with the standard (for this vehicle) pulley and air intake in the vehicle plus the mixed-flow fan. Measurements were made with the curtains up (open cab) and with the curtains down (closed cab). The second tests were made with the high-speed pulley installed with the mixed-flow fan and the standard air intake. The same procedure was followed when the modified air intake was installed except that additional measurements were made with the inboard side of the modified air intake blocked off with a piece of cardboard.

All of the SPL's were read from the meter on the octave band analyzer, General Radio (GR) Type 1558-BP. The GR Type 1560-P6 microphone system was used with the analyzer. All of the test runs were tape recorded with the Nagra III recorder.

Pilot Vehicle No. 1 Test -- August 1968

These cab measurements were made 24 August 1968 at Aberdeen Proving Ground, Md.

The vehicle was used with an open cab and an open cargo area (no cover or curtains on cab or cargo area). It was equipped with the modified air intake, the mixed-flow engine cooling fan, and the high-speed fan belt pulley.

The first part of the test was run with one-inch coated glass fiber installed in the exhaust air shroud. The engine was run at 2000, 3000, 4000 and 4350 (maximum) rpm. The second part of the test was run with the fiber glass removed from the exhaust shroud. The engine speeds were the same as for the first part of the test. The noise of all test runs was recorded on magnetic tape.

Pilot Vehicle No. 6 Test -- July and August 1969

Detection measurements were made 50 feet from each side of the vehicle and 50 feet in front and to the rear of the vehicle. The microphone was held by hand about four feet above the ground with the microphone facing up.

The first measurements were made 1 July 1969 in the cab with the curtains up (open cab) and curtains down (closed cab) while the engine was operated at 1000, 2000, 3000, 4000 and 4500 rpm. Measurements were made at 4000 and 4500 rpm with the side curtains up and the rear curtain down. The acoustical material in the exhaust air shroud was approximately one-third glass fiber and two-thirds plastic foam. The radiator shroud, the modified air intake, and the engine compartment contained the glass fiber that had been installed in 1968.

The vehicle was next measured 8 July 1969 after all acoustical material had been removed. Cab levels were measured with the curtains up and curtains down at 1000, 2000, 3000, 4000 and 4500 rpm. Again, 50-foot detection measurements were taken at 3000, 4000 and 4500 rpm.

On 10 July 1969, cab measurements (curtains up and curtains down) were made at 1000, 2000, 3000, 4000 and 4500 rpm after one-inch plastic foam had been installed in the exhaust air shroud (Fig. 5). Plastic foam was next installed in the radiator shroud and the cab measurements repeated, with the curtains down, at the same engine speeds. Next, the foam was added to the modified air intake and the measurements made with the curtains down.

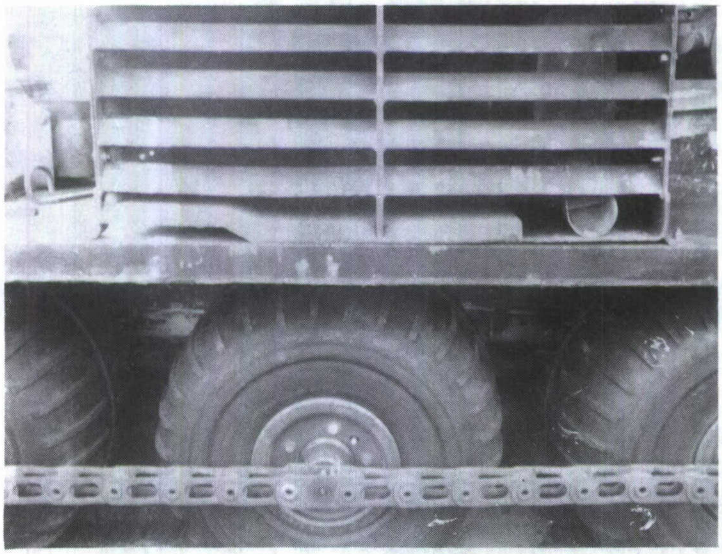

Fig. 5. VIEW OF EXHAUST AIR SHROUD WITH PLASTIC FOAM

On 11 July 1969, all measurements were made in the cab with the curtains down at 4000 and 4500 rpm. The first condition was with the engine cooling fan disconnected; the second was without the modified air intake, radiator shroud and muffler; the third was without the radiator shroud and the modified air intake; the fourth was without the steer-gear pump; and the fifth was without the modified air intake.

The next measurements were made 7 August 1969 in the cab with the curtains up and with the modified air intake removed. The plastic-foam material was still in the exhaust and radiator shrouds. The engine was operated at 4000 and 4500 rpm.

Plastic foam was then added to the underside of the engine compartment hatch followed by measurements at 3000, 4000 and 4500 rpm with the curtains up and then with the curtains down.

The next addition of the plastic foam was made under and behind the seat panels which was followed by measurements at 3000, 4000 and 4500 rpm with the curtains up and down.

On 8 August 1969 more plastic foam was added to the radiator shroud and a new muffler was installed. Measurements were then made in the cab at 3000, 4000 and 4500 rpm with the curtains up, curtains down, and with side curtains up while the rear curtain was down.

Plastic foam was next added to the top nine inches of available space on the left and rear sides of the engine compartment plus the access door. Measurements were made at 3000, 4000 and 4500 rpm with the curtains up and down. A sheet of 1/4-inch plywood was fastened to the rear of the cab as a substitute for the rear curtain and measurements made at 4000 and 4500 rpm with the side curtains up.

Pilot Vehicle No. 2 Test -- September-December 1969

The first measurements were made 10 September 1969 with no acoustical material installed on the vehicle and with the engine cooling fan mounted on the right side. These measurements were made for both the open-cab and closed-cab condition at 650 (idle), 1000, 2000, 3000, 4000 and 4500 rpm.

The first installation of acoustical material, one-inch plastic foam, was cemented to the interior of the engine cooling fan housing in a one-inch wide ring next to the exhaust side of the fan stators. Measurements were made in the cab with the curtains up (open cab) at 3000 and 4000 engine rpm. Then a similar ring of the plastic foam, one inch thick and one inch wide, was cemented to the interior of the fan housing, next to the fan blades on the upstream side of the blades. Measurements were again made in the open cab at 3000 and 4000 rpm.

On 11 September 1969 the interior of the rectangular shroud covering the engine, radiator and accessories was "treated" with the one-inch plastic foam. On 12 September 1969 measurements were made in the open cab at 3000 and 4000 rpm for the following conditions:

a. Original rectangular duct installed on the exhaust side of the fan.

b. Rectangular duct replaced by a circular duct having same diameter as the fan housing.

c. No duct attached to the fan housing.

d. Circular duct lined with the plastic foam (Fig. 6).

e. Same as d plus three one-inch strips of the foam added axially to the existing foam liner.

On 15 September 1969 foam was added to the back of the cab seats (Fig. 7) and to the interior of the engine access cover (Fig. 8). SPL's were then measured at 2000, 3000 and 4000 rpm with the cab open and closed. The circular duct was removed and a one-inch strip of foam was cemented to the interior of the fan housing between the fan blades and the stators. SPL's were measured at 2000, 3000 and 4000 rpm in the open cab with no duct attached to the fan housing. The circular duct with its foam liner was replaced and the measurements repeated. The next step was the addition of a vane to the interior of the circular duct. SPL's were then measured as before with and without foam on the vane.

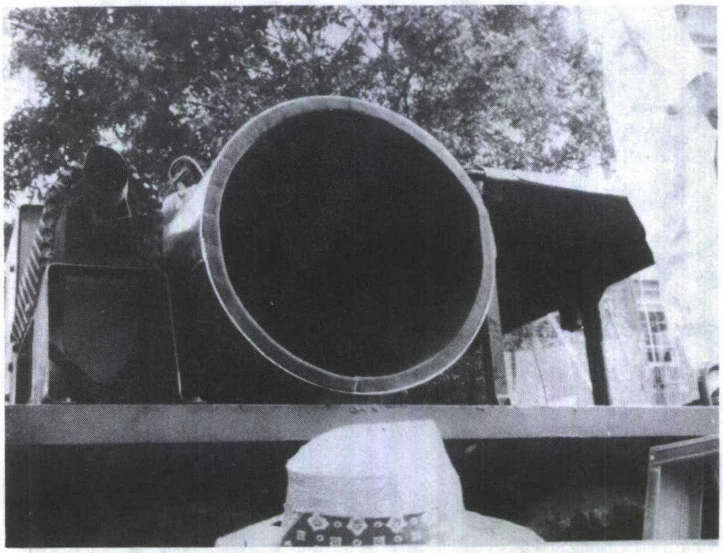

Fig. 6. VIEW OF CIRCULAR EXHAUST AIR DUCT LINED WITH PLASTIC FOAM

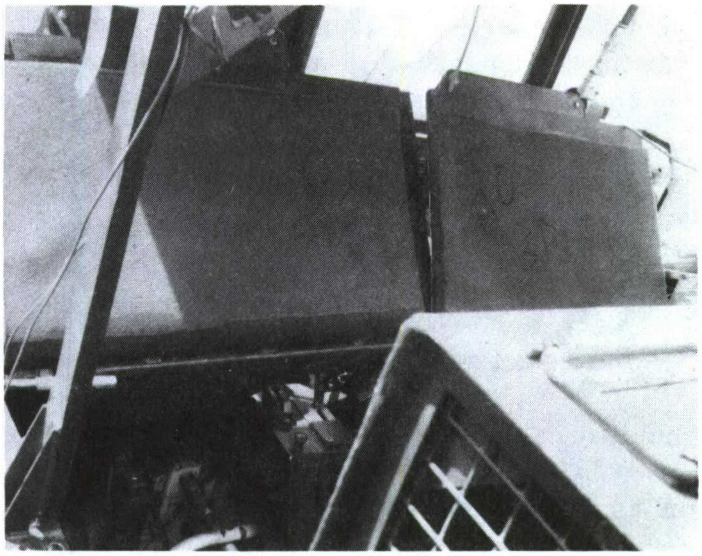

Fig. 7. VIEW OF PLASTIC FOAM ON BACK OF DRIVERS' SEATS

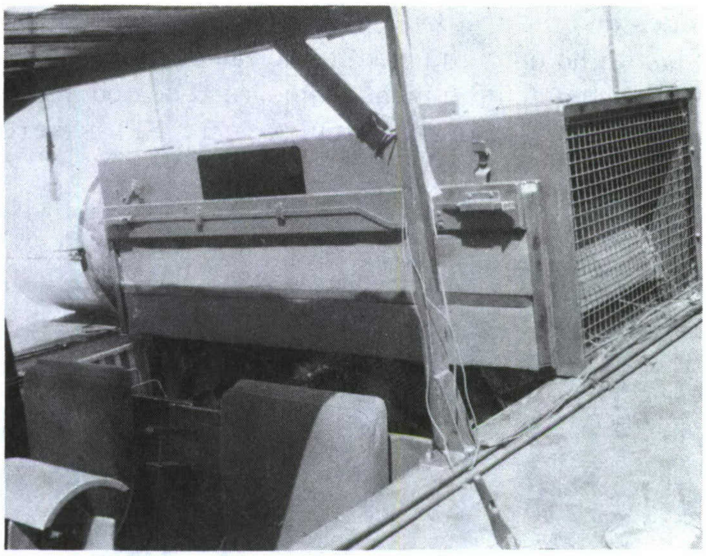

Fig. 8. ENGINE COOLING SYSTEM FOR PILOT VEHICLE NO. 2 WITH VIEW OF PLASTIC FOAM ON THE INTERIOR OF THE ENGINE ACCESS COVER

On 16 September 1969, the first measurement was made in the open cab with the fan motor and fan disconnected at 4000 engine rpm. The second condition was with the fan motor and fan operative and with the fan motor wrapped with plastic foam. The third condition was with foam added to the fan hub between the blades and the motor. The second and third condition measurements were made in the open cab at 2000, 3000 and 4000 rpm.

Testing was resumed on 19 November 1969, with the fan mounted on the left side of the vehicle (Fig. 9). The first measurements were made in the center of the open cargo area at head level of seated personnel (Fig. 10). They were made with no duct attached to the fan housing (see Fig. 9) and at 2000, 3000 and 4000 rpm. The next measurements were made at the same location in the cargo area with the Carr-Kalen (C-K) Attenuator shown in Figure 11. These measurements were made at 3000 and 4000 engine rpm.

The microphone was relocated in the cab and SPL's measured with the cab open at 1000, 2000, 3000 and 4000 rpm. There was no attachment (duct or attenuator) mounted to the fan housing at this time. The cab was then closed and SPL's measured at 2000, 3000 and 4000 rpm.

The C-K Attenuator was attached to the fan housing and measurements made in the cab (closed and open) at 2000, 3000 and 4000 rpm. Testing was stopped at this time because the fan belts had been burned by the engine exhaust.

Testing was resumed 1 December 1969 after new belts were installed and the exhaust relocated. The first measurements on this date were a repetition of the last made 19 November in the cab with the C-K Attenuator.

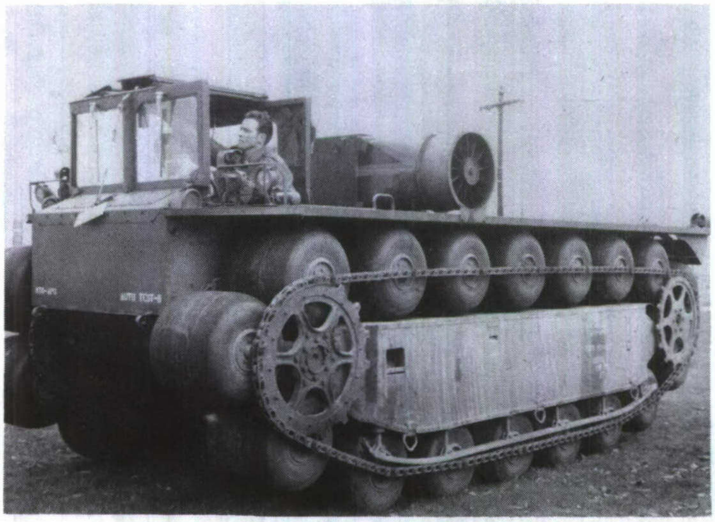

Fig. 9. PILOT VEHICLE NO. 2 WITH FAN MOUNTED ON LEFT SIDE

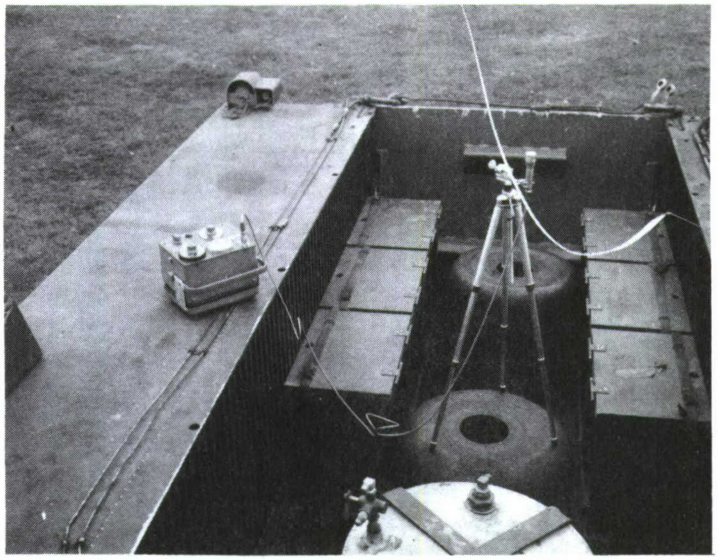

Fig. 10. VIEW OF MEASURING SYSTEM IN CARGO AREA OF PILOT VEHICLE NO. 2

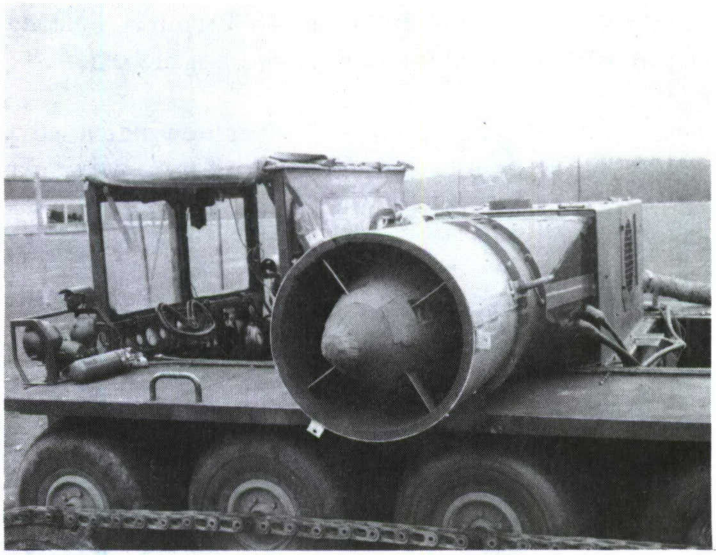

Fig. 11. CARR-KALEN ATTENUATOR ON PILOT VEHICLE NO. 2

RESULTS

All of the noise level results presented in this report are data obtained in the drivers' cab with the vehicles stationary and with the engines and cooling fans operating (except for the few cases when the fans were disconnected). The presentation of data involves Pilot Vehicles No. 2, No. 3 and No. 6. Data for Pilot Vehicles No. 3 and No. 6 have been presented on the same figures, while data for Pilot Vehicle No. 2 have been presented on separate figures. The reason for this method of presentation was the difference in location of the engine cooling system. Pilot Vehicles No. 3 and 6 had a system drawing air into the radiator directly behind the cab and exhausting the air out on the right side of the vehicles (Fig. 12). Pilot Vehicle No. 2 had a system drawing air in on one side of the vehicle and exhausting it on the opposite side (Fig. 8). The SPL results by octave bands are shown in Figures 14-31.

Another presentation is one showing detection distances for an acoustically treated vehicle versus an untreated vehicle. Pilot Vehicle No. 6 was used for these measurements and the distances are shown in Figure 13. These distances represent those distances which a person with keen hearing could hear the noise from the XM759 Cargo Carrier.

DISCUSSION

The main source of noise in the XM759 Cargo Carrier is the engine cooling fan. This is vividly revealed by Figures 14 and 15, with and without the operation of the fan. High-speed cooling fan noise is a problem in many U. S. Army vehicles.

The fan noise in Pilot Vehicles No. 3 and 6 was reduced by substituting a mixed-flow fan for the original axial-flow fan and by using acoustical material in the engine compartment, in the cooling system, and on the drivers' seats. In Pilot Vehicle No. 2, the fan noise was reduced by adding an attenuator to the exhaust side of the fan housing and foam in the engine compartment, in the cooling system, and on the drivers' seats. The attenuator helps to reduce the noise level but has the serious disadvantage of restricting the flow of cooling air and thereby raising the engine operating temperature.

It is believed that even more reduction can be obtained through more research by fan manufacturers and designers. A technique has been developed for selecting circumferentially-unequal blade spacings that reduce the tonal annoyance of the aerodynamic noise generated by the rotors of fans.* The procedure has been successfully applied to a number of axial-flow fans.

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* Mellin, R. C. & Sovran, G. Controlling the tonal characteristics of the aerodynamic noise generated by fan rotors. Transactions of the ASME Journal of Basic Engineering, Paper No. 69-WA/FE-23 (1969).

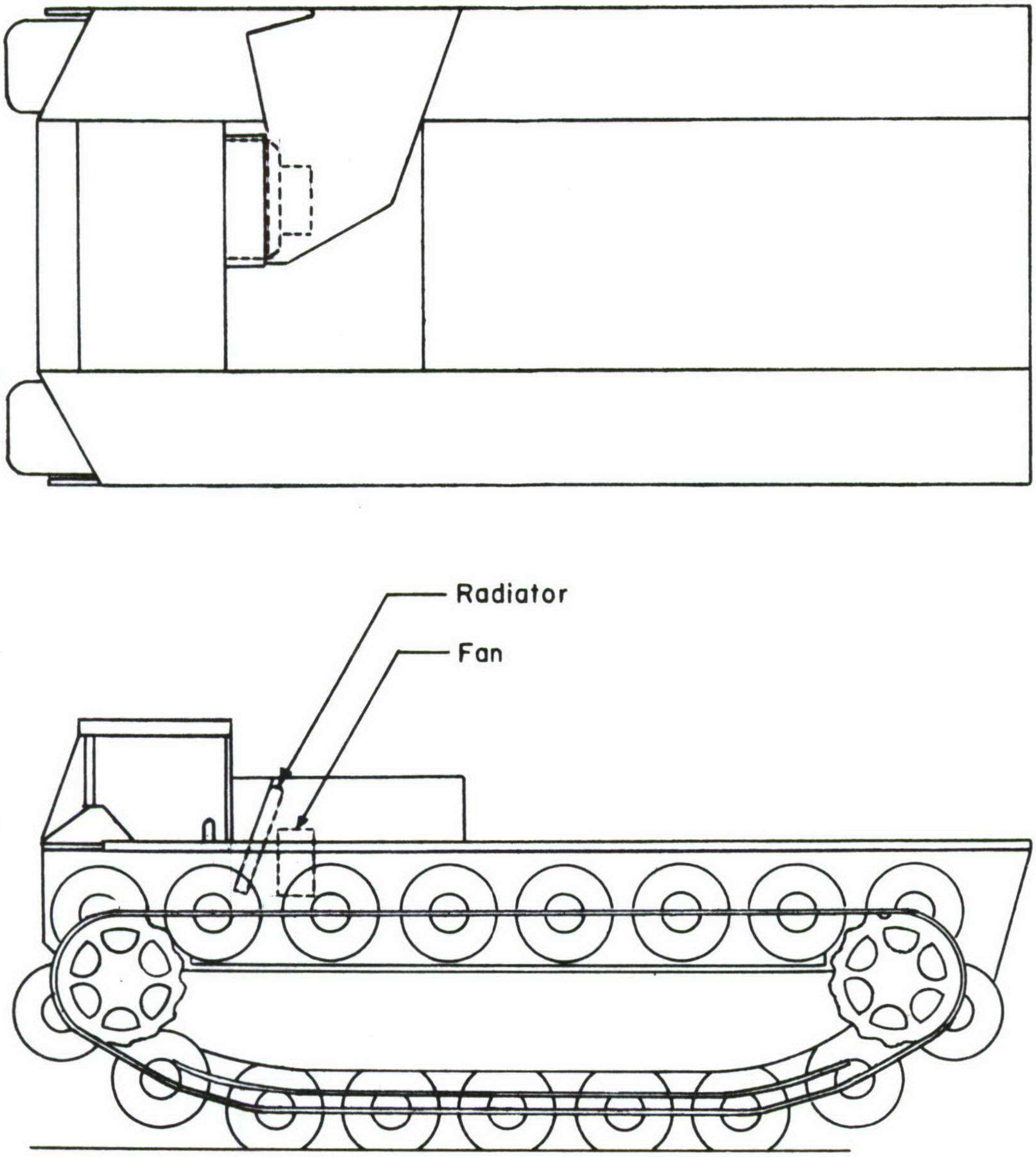

Fig. 12. VIEWS OF FAN AND RADIATOR IN PILOT VEHICLES NO. 3 AND NO. 6

Another improvement would be the use of variable speed fans whose speed would vary with the ambient air temperature. This type of fan would require less power to operate than one where the fan speed is dependent upon the engine speed.

In the tests covered by this report the acoustical attenuating materials used were either glass fiber or plastic foam. Both of these materials have disadvantages. The glass fiber is easily eroded by the cooling air passing by the fiber surface. The plastic foam will melt if placed too near the engine exhaust system. A metallic attenuating material, some of which are used in commercial aircraft, would not be affected by the air stream or the engine exhaust system.

CONCLUSIONS AND RECOMMENDATIONS

1. The major noise source in this vehicle is the engine cooling fan.

2. It is recommended that this vehicle and all other U. S. Army vehicles requiring high-speed cooling fans be provided with variable speed fans.

3. It is recommended that a metallic type of acoustical attenuating material be considered for use with all vehicles.

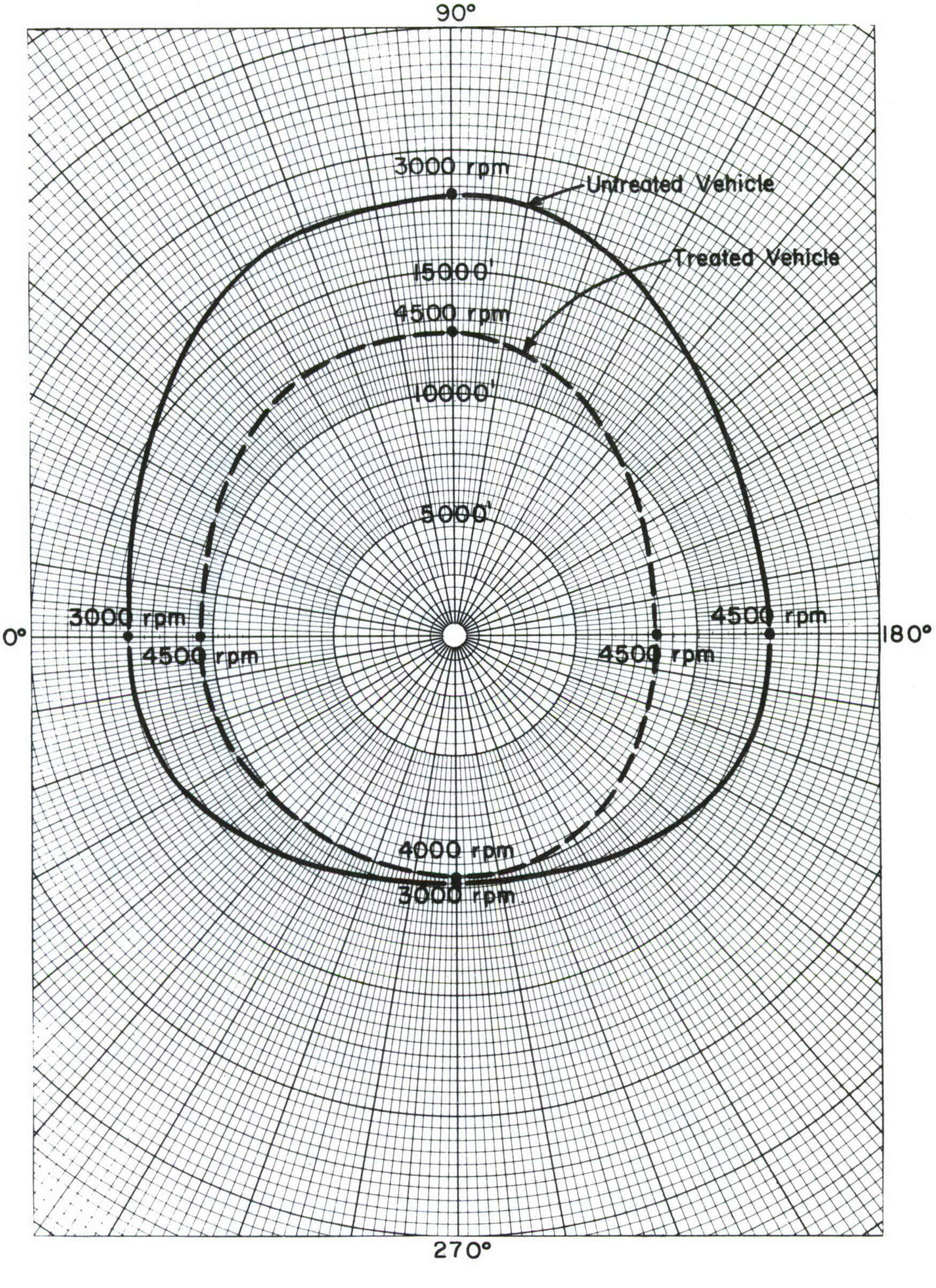

Fig. 13. DETECTION DISTANCES FOR AN UNTREATED AND TREATED PILOT VEHICLE NO. 6. VEHICLE HEADING IS 0°

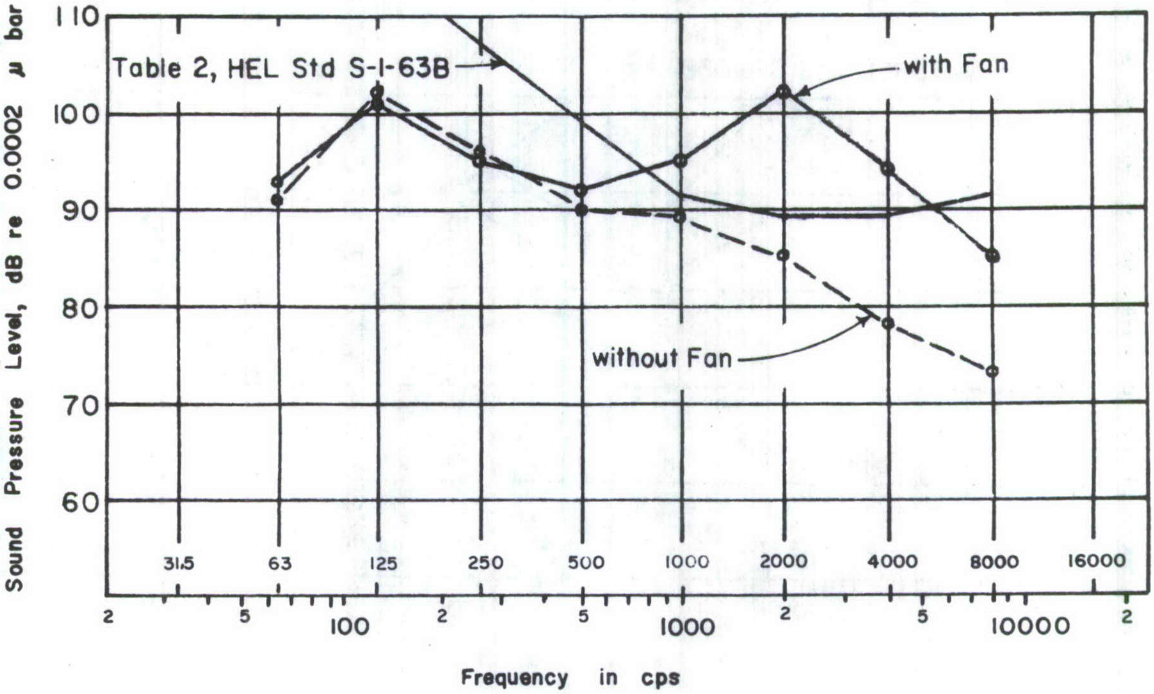

Fig. 14. OCTAVE BAND ANALYSES OF NOISE IN CAB OF PILOT VEHICLE NO. 3 AT 4000 ENGINE RPM WITH AND WITHOUT THE FAN

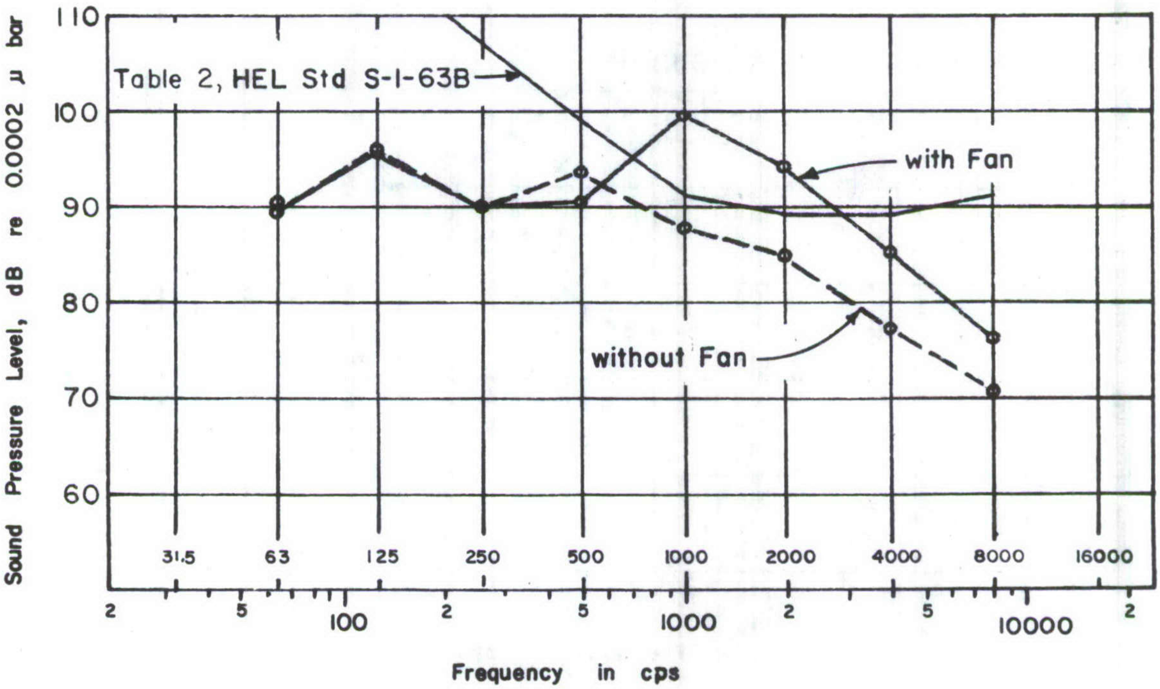

Fig. 15. OCTAVE BAND ANALYSES OF NOISE IN CAB OF PILOT VEHICLE NO. 2 AT 4000 ENGINE RPM WITH AND WITHOUT THE FAN

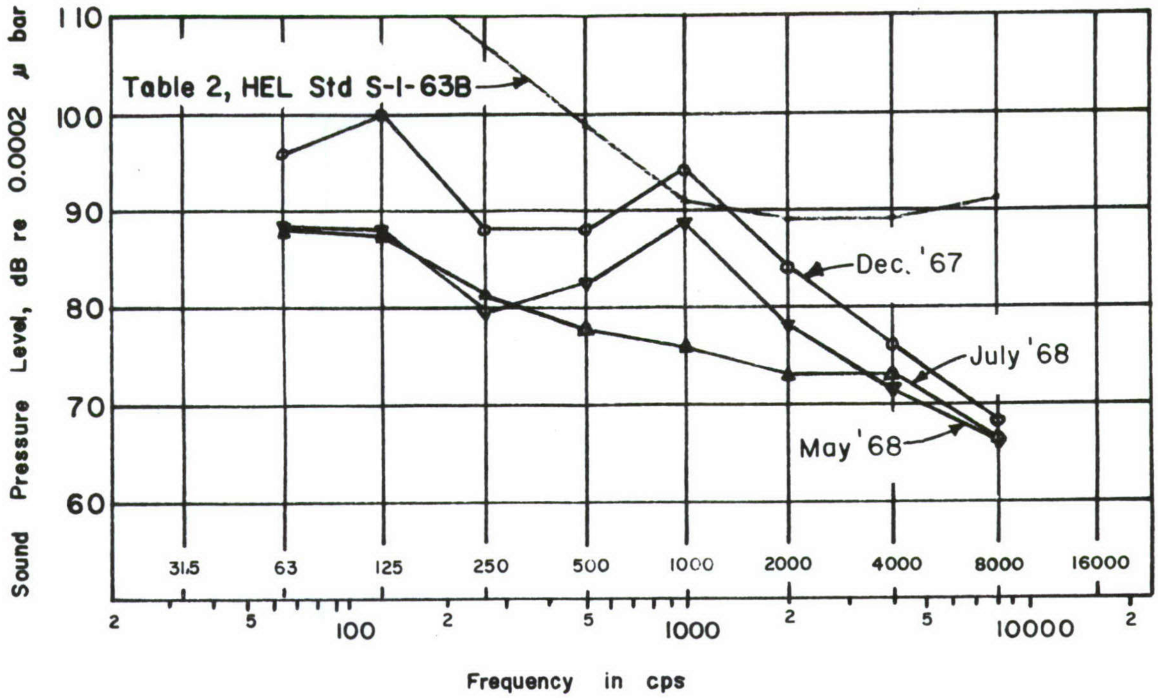

Fig. 16. CAB NOISE IN PILOT VEHICLE NO. 3 (DEC 1967) AND PILOT VEHICLE NO. 6 (MAY & JULY 1968) AT 2000 ENGINE RPM. CAB WAS CLOSED EXCEPT FOR PILOT VEHICLE NO. 3 WHERE DRIVER'S CURTAIN WAS OFF

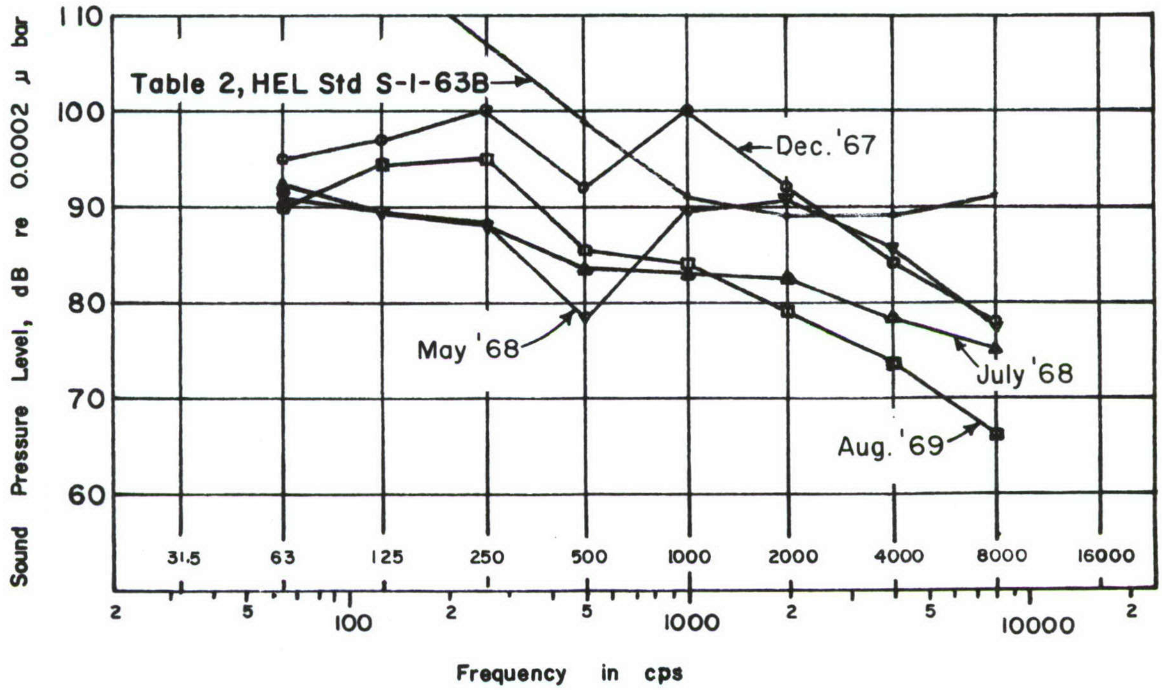

Fig. 17. CAB NOISE IN PILOT VEHICLE NO. 3 (DEC 1967) AND PILOT VEHICLE NO. 6 (MAY & JULY 1968; AUG 1969) AT 3000 ENGINE RPM. CAB WAS CLOSED EXCEPT FOR PILOT VEHICLE NO. 3 WHERE DRIVER's CURTAIN WAS OFF

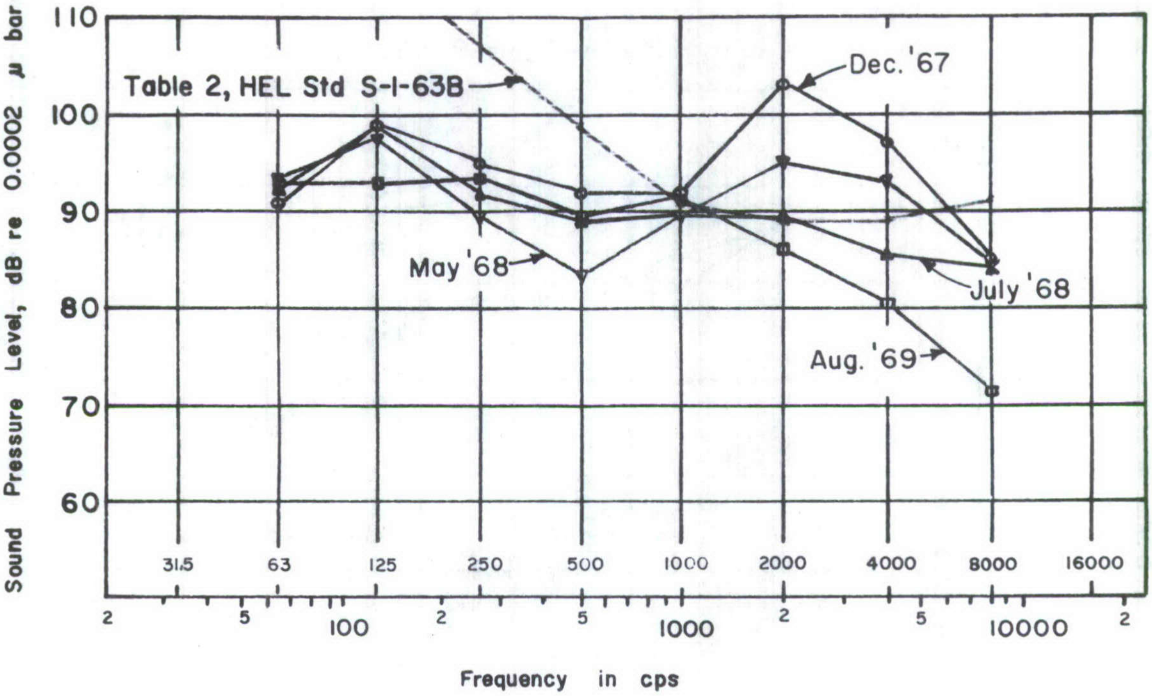

Fig. 18. CAB NOISE IN PILOT VEHICLE NO. 3 (DEC 1967) AND PILOT VEHICLE NO. 6 (MAY & JULY 1968; AUG 1969) AT 4000 ENGINE RPM . CAB WAS CLOSED EXCEPT FOR PILOT VEHICLE NO. 3 WHERE DRIVER'S CURTAIN WAS OFF

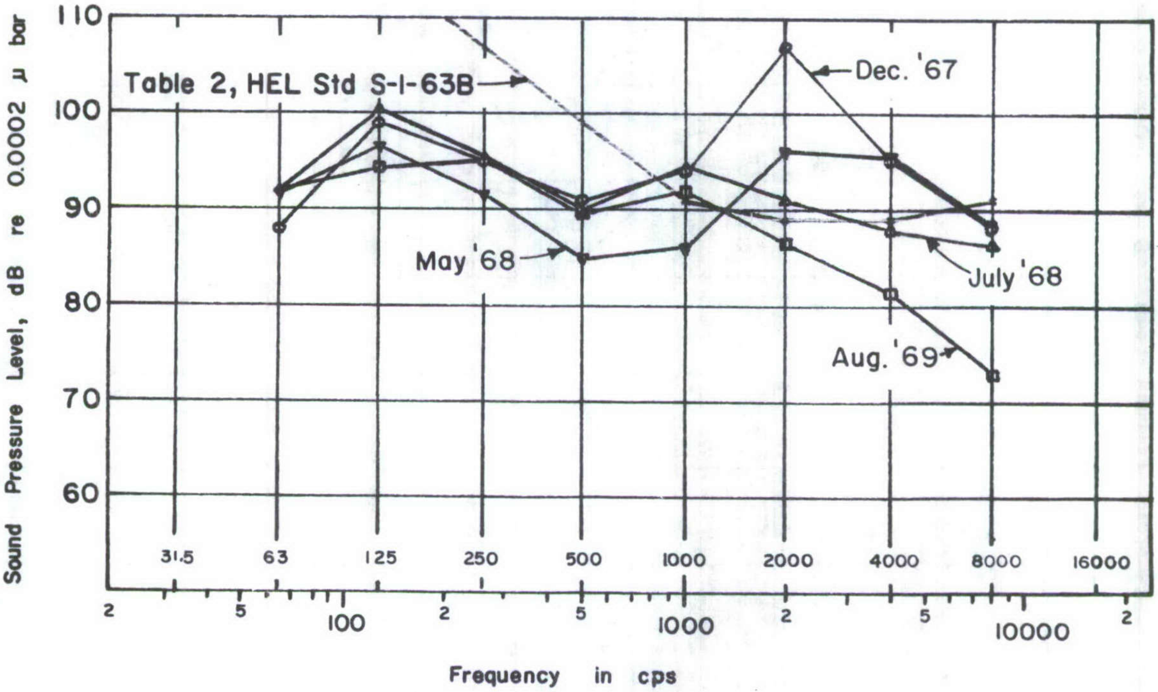

Fig. 19. CAB NOISE IN PILOT VEHICLE NO. 3 (DEC 1967) AND PILOT VEHICLE NO. 6 (MAY & JULY 1968; AUG 1969) AT 4500 ENGINE RPM. CAB WAS CLOSED EXCEPT FOR PILOT VEHICLE NO. 3 WHERE DRIVER'S CURTAIN WAS OFF

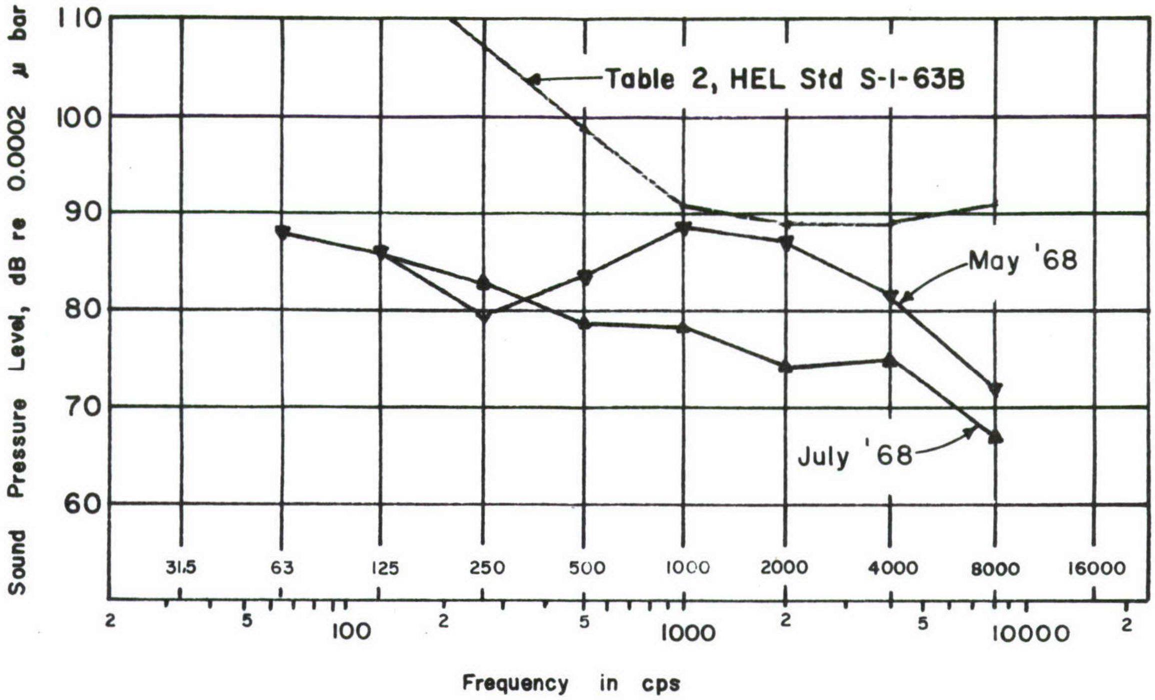

Fig. 20. OPEN CAB NOISE IN PILOT VEHICLE NO. 6 AT 2000 ENGINE RPM

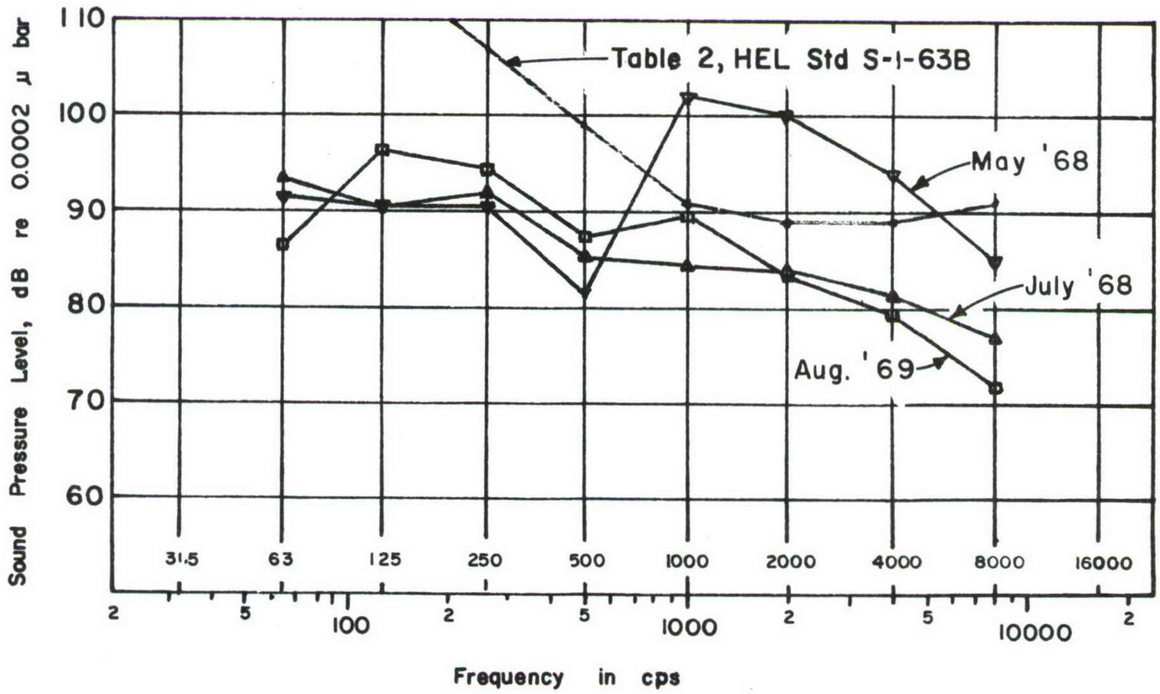

Fig. 21. OPEN CAB NOISE IN PILOT VEHICLE NO. 6 AT 3000 ENGINE RPM

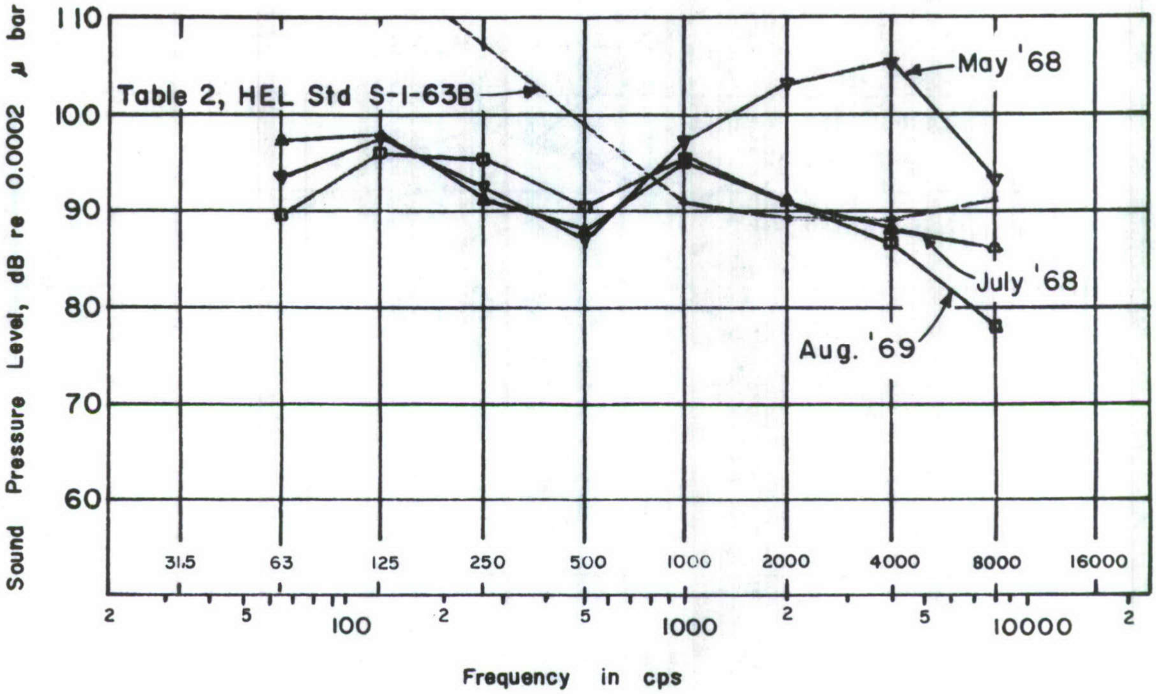

Fig. 22. OPEN CAB NOISE IN PILOT VEHICLE NO. 6 AT 4000 ENGINE RPM

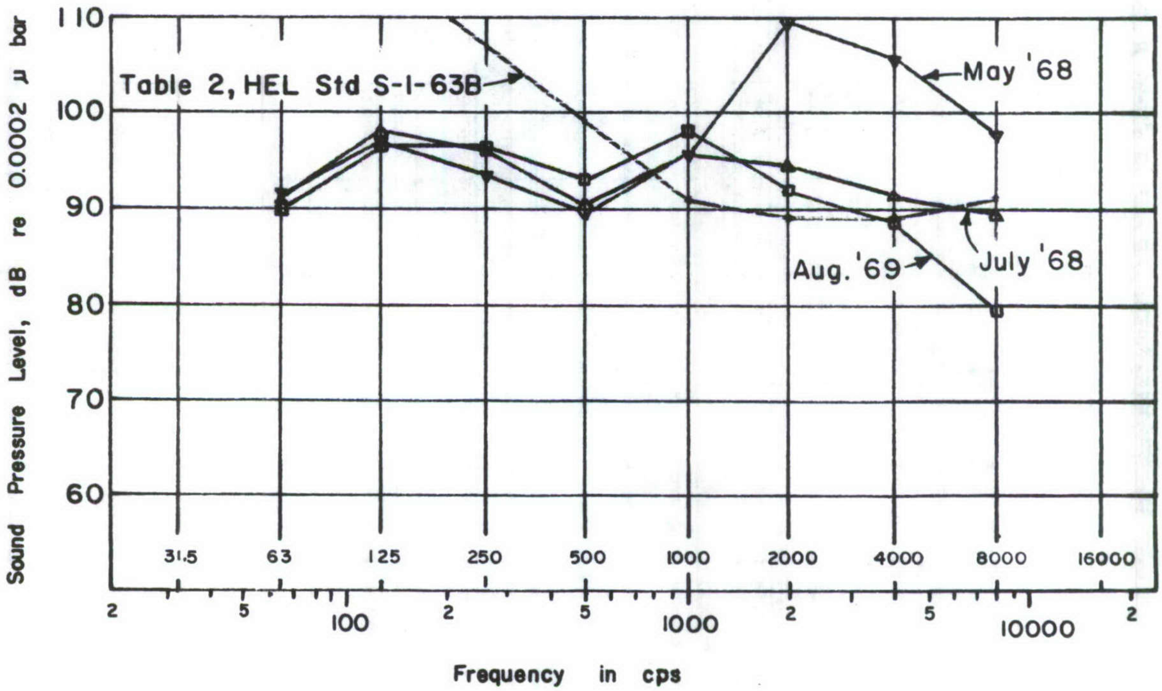

Fig. 23. OPEN CAB NOISE IN PILOT VEHICLE NO. 6 AT 4500 ENGINE RPM

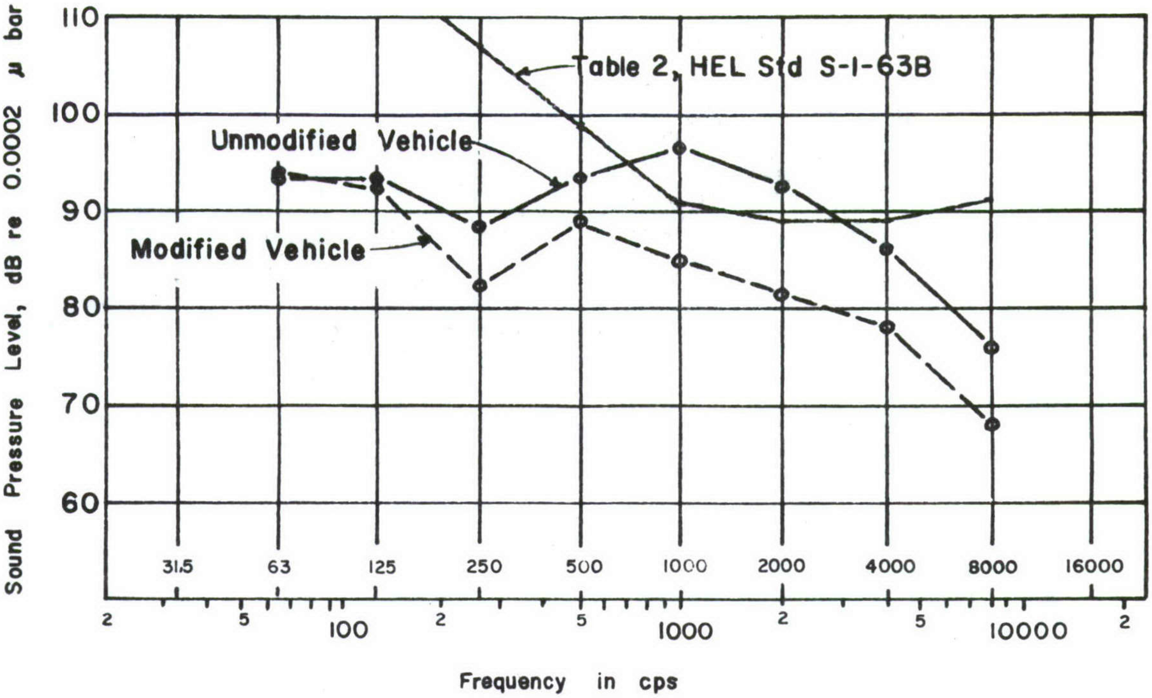

Fig. 24. CLOSED CAB NOISE IN PILOT VEHICLE NO. 2 AT 2000 ENGINE RPM

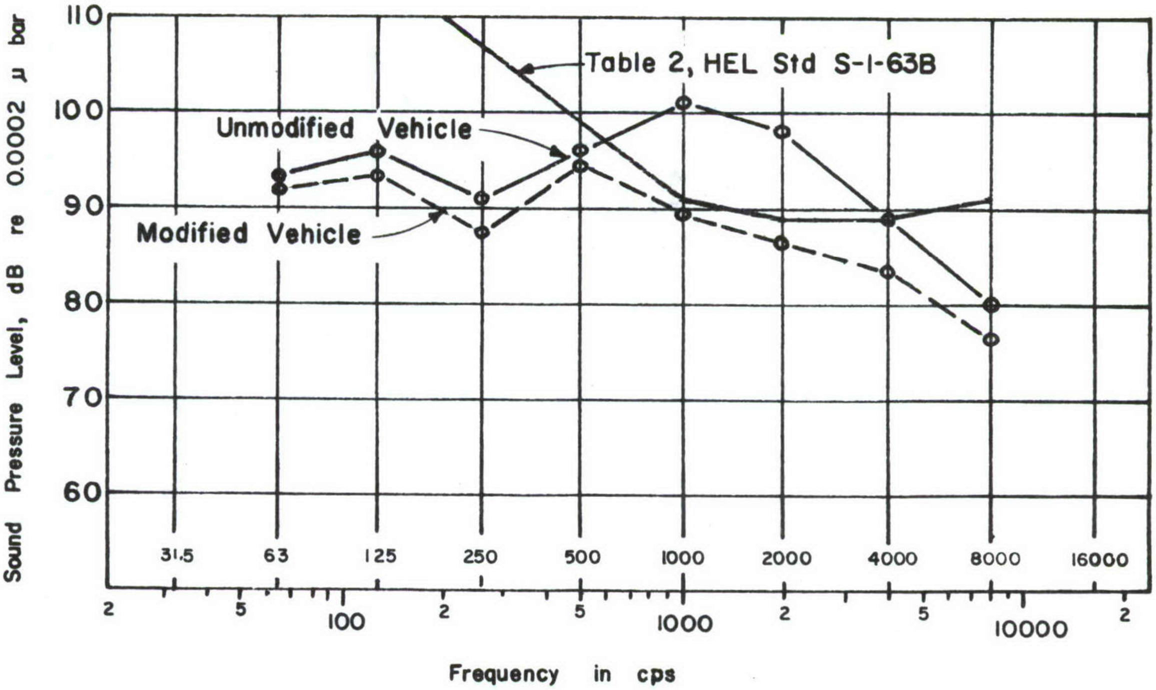

Fig. 25. OPEN CAB NOISE IN PILOT VEHICLE NO. 2 AT 2000 ENGINE RPM

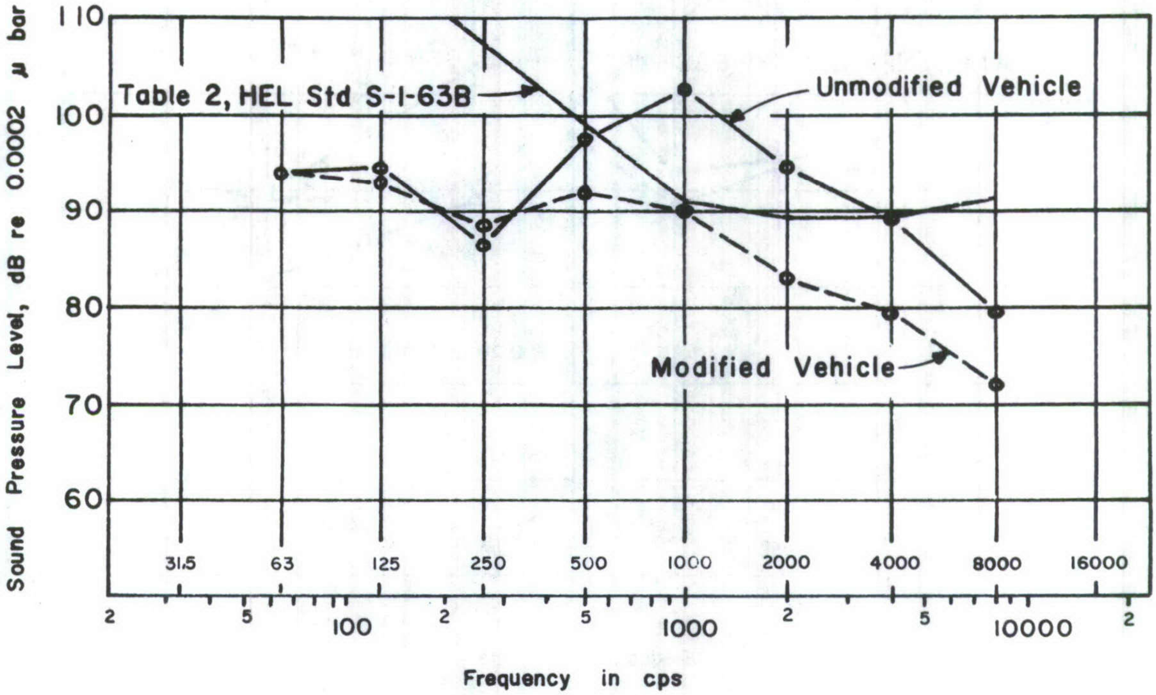

Fig. 26. CLOSED CAB NOISE IN PILOT VEHICLE NO. 2 AT 3000 ENGINE RPM

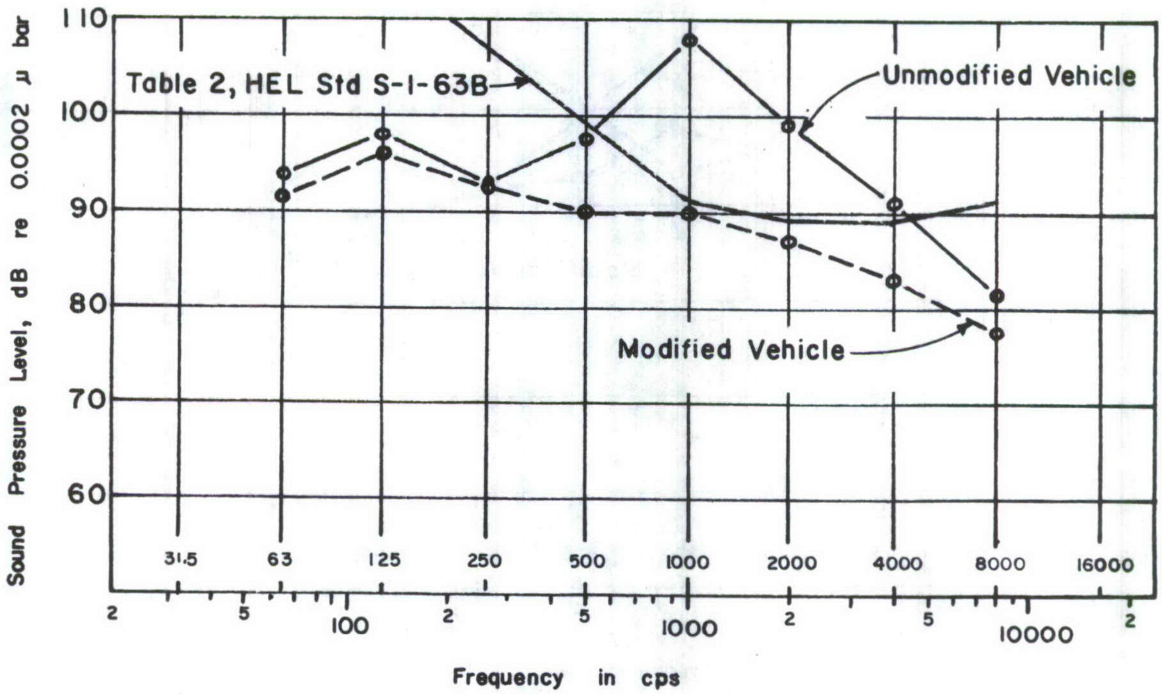

Fig. 27. OPEN CAB NOISE IN PILOT VEHICLE NO. 2 AT 3000 ENGINE RPM

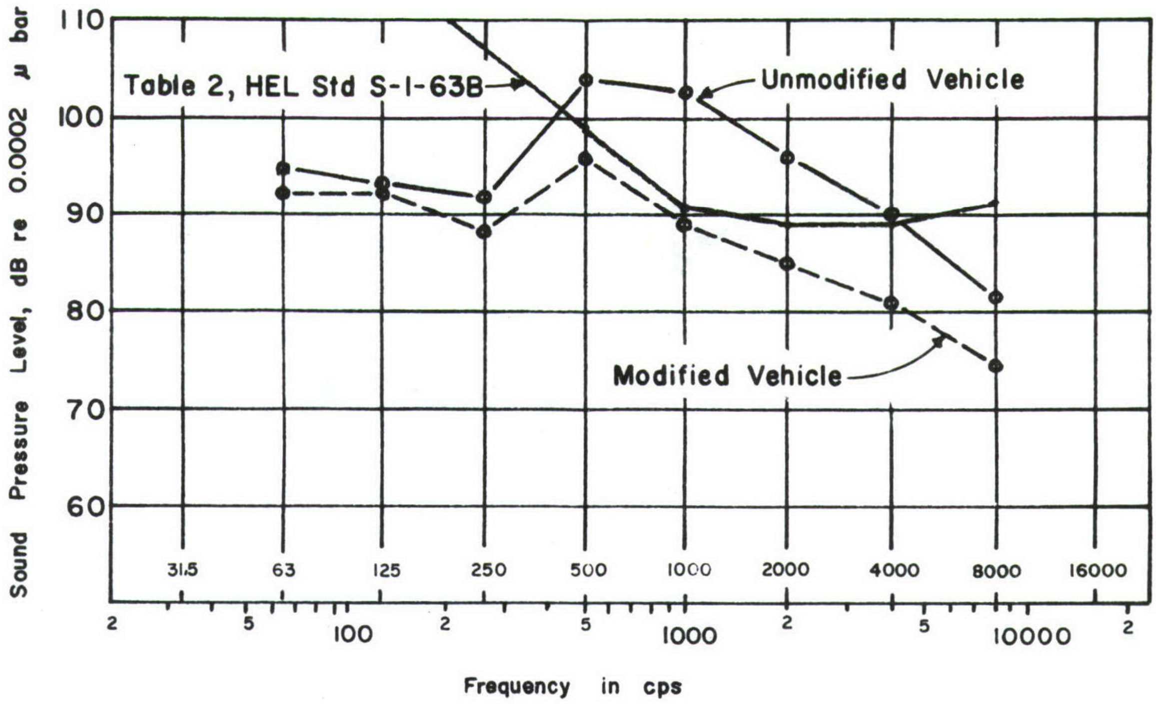

Fig. 28. CLOSED CAB NOISE IN PILOT VEHICLE NO. 2 AT 4000 ENGINE RPM

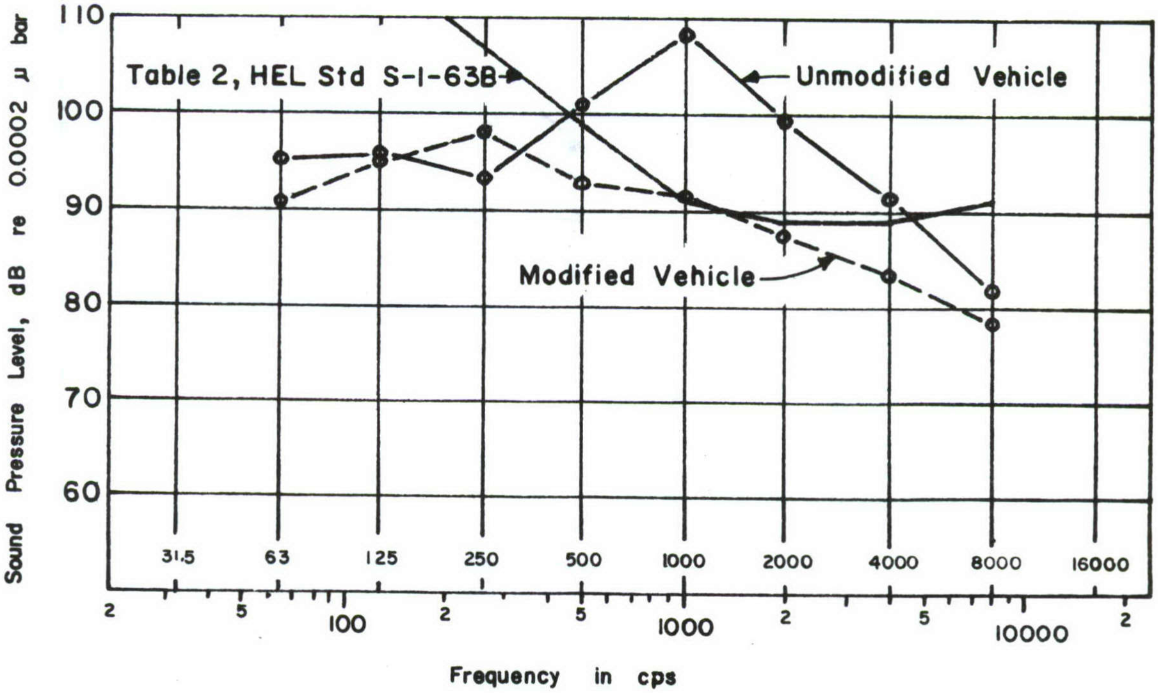

Fig. 29. OPEN CAB NOISE IN PILOT VEHICLE NO. 2 AT 4000 ENGINE RPM

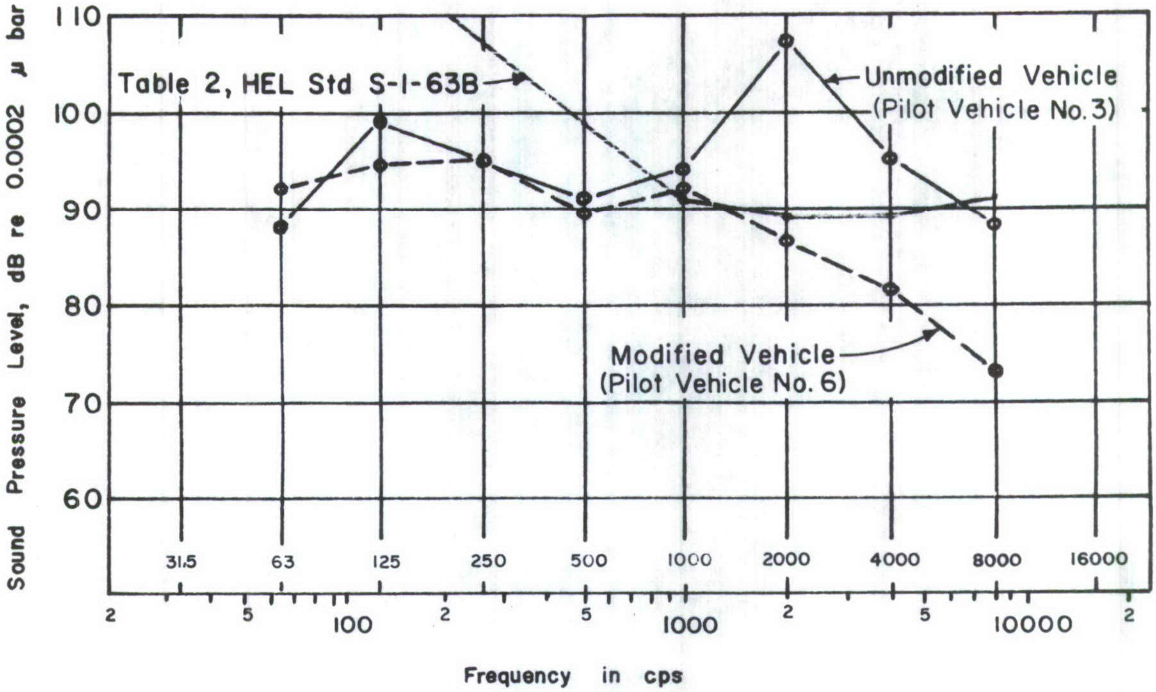

Fig. 30. AN OCTAVE BAND ANALYSIS OF THE CAB NOISE AT 4500 ENGINE RPM BEFORE AND AFTER MODIFICATIONS FOR NOISE REDUCTION (Note the large change in the 2000 cps band caused by reducing the pure tone noise of the fan. Vehicle No. 6 data is for a closed cab and Vehicle No. 3 is for a cab with the driver's curtain off.)

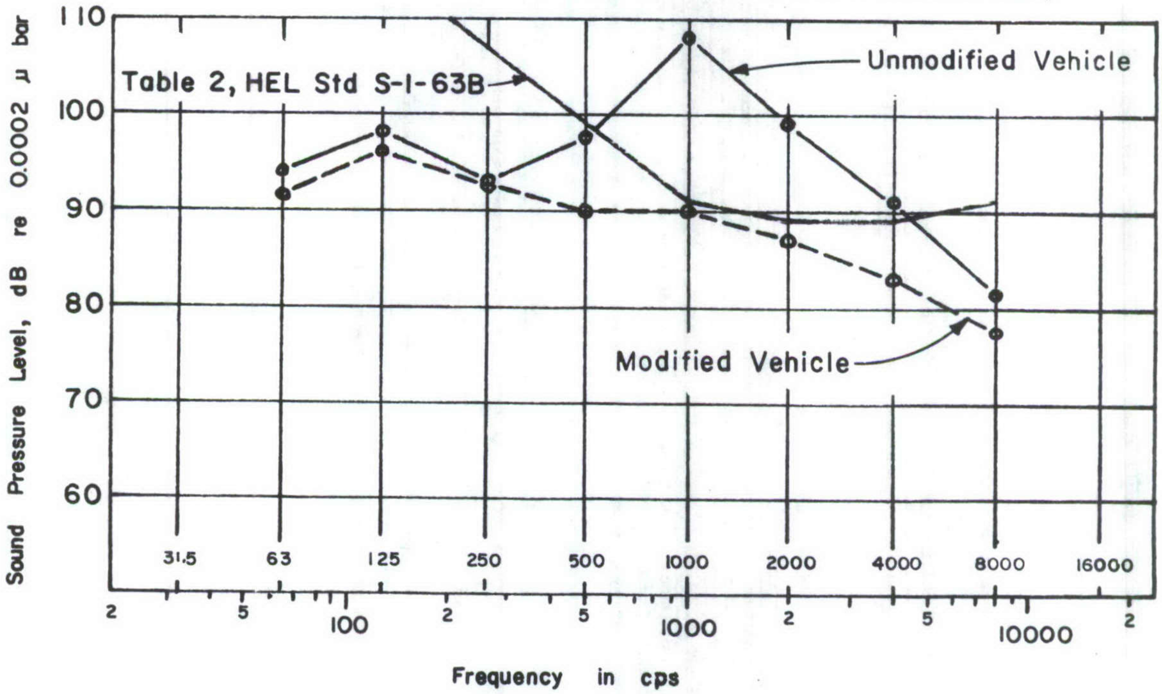

Fig. 31. AN OCTAVE BAND ANALYSIS OF OPEN CAB NOISE AT 3000 ENGINE RPM IN PILOT VEHICLE NO. 2 BEFORE AND AFTER MODIFICATIONS FOR NOISE REDUCTION (Note the large change in the 1000 cps band caused by reducing the pure tone noise of the fan.)

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13. ABSTRACT

Noise was reduced on the XM759 Cargo Carrier (Marginal Terrain Vehicle) by changing the type of engine cooling fan, applying acoustical attenuating material, and using a noise attenuator. The main noise source is the engine cooling fan. Pilot Vehicles 1, 2, 3, and 6 were involved in this noise reduction program, which began in December 1967 and is still in progress.

14. KEY WORDS	LINK A		LINK B		LINK C	
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